

APPLICATION FOR UNITED STATES PATENT

INVENTORS: **PENG CHEN; ROGER IBBOTSON;
MICHAEL C. HENKEL**

ASSIGNEE: **IBBOTSON ASSOCIATES, INC.**

TITLE: **AUTOMATICALLY ALLOCATING AND
REBALANCING DISCRETIONARY
PORTFOLIOS**

PIPER RUDNICK
Suite 1800
203 North LaSalle Street
Chicago, Illinois 60601-1293
Attorneys

Telephone: (312) 368-4000
Facsimile: (312) 236-7516

**AUTOMATICALLY ALLOCATING AND REBALANCING
DISCRETIONARY PORTFOLIOS****TECHNICAL FIELD OF THE INVENTION**

The present invention relates in general to investment portfolio management, and more particularly to automatically allocating and rebalancing portfolios based on the age, financial condition and other attributes of an investor, as well as the future market performance of his/her portfolio.

BACKGROUND OF THE INVENTION

It is widely understood that workers should save a portion of their earnings to fund their retirement and other long-term goals, and invest these savings in a prudent manner so as to balance risk and return. Many employers have established benefit plans by which this may be accomplished, such as 401(k) retirement accounts and defined contribution pension plans.

It is common practice for employees to initially set up these plans to invest different percentages of the employee's contribution to different assets, such as different mutual funds, having differing degrees of risk and different rates of expected return. The worker is almost always given the discretion to change the percentage allocations made to various assets, and account managers usually even maintain a web site for this purpose, but empirical studies (e.g. "How Do Household Portfolio Shares Vary with Age?" Columbia University working paper, (2001) by John Ameriks and Stephen P. Zeldes) suggest that only a small minority, on the order of twenty percent, of all such workers actually make any alterations. The majority of all workers keep the initial allocations, and do not change them even in view of significant changes in their age, economic condition or need. As a result, what may have been a prudent allocation at the beginning begins to depart from the allocations which are optimum in view of advancing age, improving or deteriorating economic condition, newly available investment vehicles, or alterations in the performance characteristics of the assets that had been initially selected.

Recently, a concept called "Human Capital" has been used in computing what an investor should do given his or her present situation and age. Human Capital can be simply defined as the present value of future labor income or

the actuarial present value of future savings directed toward retirement saving in the contexts of retirement portfolio management. The variables important to the calculation of Human Capital include future labor income, the amount of retirement savings in qualified retirement vehicles (such as 401(k) and IRA plans) and nonqualified retirement vehicles (such as taxable accounts and variable annuities), current age, retirement age, mortality and life expectancy, gender, real long-term interest rate, defined benefit pension income if any and social security income. The impacts of Human Capital on investor's portfolio choices have been studies in "Labor Supply Flexibility and Portfolio Choice in a Life Cycle Model," Journal of Economic Dynamics and Control, Vol. 16, 427-449 (1992); "Why Should Older People Invest Less in Stocks than Younger People?" Federal Reserve Bank of Minneapolis Quarterly Review, 20(3), 11-23 (1996); "An Expanded Portfolio View Includes Real Estate and Human Capital", American Association of Individual Investors Journal, 7-11 (July 1996), by Charles Delaney and William Reichenstein; "Subjective And Objective Risk Tolerance; Implications For Optimal Portfolios," Financial Counseling and Planning, Vol. 8, (1997) by Sherman Hanna and Peng Chen; "Optimal Portfolio Choice for Long-Horizon Investors with Nontradable Labor Income," Working Paper: Harvard University (1998) by Luis Viceira; and "Investing Retirement Wealth: A Life Cycle Model," NBER Working Paper Number 7029 (1999).

Although the impact of Human Capital on investor portfolio choices have been studied by many academics, this concept has not been used in the management of retirement plans or to automatically switch allocations of assets in the portfolio of an investor or plan participant.

SUMMARY OF THE INVENTION

The invention provides systems, methods and computer program products for the automated allocation and reallocation of assets in each of a plurality of investor portfolios. These investors may, for example, be participants in an employer's defined contribution retirement plan. According to one aspect of an invention, an automated plan manager allocates assets to each of a plurality of plan participant portfolios according to optimum portfolio choices made in view of the human capital of the participant. The plan manager makes investments among several investment vehicles for the participant according to investment advice transmitted to it by an automated, independent financial expert or advisor.

In one embodiment, the independent financial expert in turn retrieves data about each participant from the company or institution employing the participant or one or more other record keepers holding the requisite information about the participant, and retrieves other data from the participant himself or herself. As a first step and using these data, the independent financial expert calculates a present value of the human capital of the participant. It allocates the human capital among predetermined investment vehicle types to take into account the overall risk/return character of the earnings of a participant's likely work life. In a preferred embodiment, the human capital of the investor is treated as a 70% fixed income, 30% equity investment.

The total human capital of the investor is summed with the present financial assets of the investor to obtain a total present worth of an overall "portfolio". The algorithm uses a predetermined, optimum distribution of assets among investment vehicle or asset class types for this overall portfolio; in a preferred

embodiment, this allocation is 42% equity and 58% fixed income. Then, by subtracting the human capital components from the total present worth, an allocation of the financial wealth assets of the investor is determined. This allocation typically will be more strongly skewed toward the equity side, than the allocation of the human capital, such that the sum of the human capital and the financial wealth components of the overall portfolio result in, or come as close as possible to, the optimum allocation.

According to another aspect of the invention, an automated, independent financial consultant or advisor uses an algorithm to formulate advice concerning the holdings of the portfolio of each of a plurality of plan participants. Absent a contrary indication from the participant, this advice is used to direct an automated plan manager to make investments for the portfolio in certain predetermined investment vehicles according to the advice from the independent financial consultant. Preferably, this algorithm is used periodically to reallocate portfolio assets to conform to an optimum model.

In another aspect of the invention, the algorithm includes a calculation of the human capital of the plan participant, and a recalculation of the human capital of the plan participant at a later time. The human capital component of a participant's overall present worth typically decreases over time. Since the human capital component of this worth is by nature a conservative investment, in order to have an overall "portfolio" of the same balance among assets of varying risk and return, a remaining, financial component of the net worth has to be shifted from assets which are more risky but which may give a greater return to assets which are safer.

In still another aspect of the invention, a method, system and computer-readable medium are provided for determining at least one savings rate and

a retirement age of a plan participant. A system according to this aspect of the invention receives data concerning the current financial wealth of the plan participant, and automatically allocates portions of that current financial wealth to one or more asset classes based on the characteristics of the investment vehicles making up the financial wealth of the participant. The system further receives at least one currently existing and a first assumed retirement age. This system calculates a first case for a probably retirement income using the current financial wealth of the participant as assigned to the asset classes, the currently extant savings rate and the first assumed retirement age. The system calculates additional cases of probable retirement income by varying at least one of the savings rates and the retirement age. The participant selects one of these cases. The system then makes investments in the plan for the investor using the selected savings rate. This method also has application for investors who are not plan participants.

A principal technical advantage of the invention is that through the automated independent financial consultant, and especially where the plan is set up such that the "default" condition is to have the independent financial consultant make investment decisions on the portfolio rather than the plan participant, the assets of a retirement portfolio can be given an optimum allocation. Further, the portfolio no longer requires the active participation of the participant to reallocate assets to take into account the advancing age and/or changing economic condition of the participant. The independent financial consultant periodically rebalances the portfolio given the characteristics of the participant in a way which removes any conflict of interest between the role of the financial adviser, who recommends the contents of participant portfolios, and the role of a plan manager, who buys and sells these assets.

The present invention also has application to the management of taxable investor portfolios, i.e., the assets of an investor that are not in one or more nontaxable retirement plans.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
2217
2218
2219
2220

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the invention may be discerned in the following Detailed Description when read in conjunction with the Drawings, in which like characters denote like parts and in which:

5 FIG. 1 is a block diagram of a benefit plan management system according to the invention;

 FIGS. 2a – 2c constitute a flow diagram showing operation of automated independent financial advisor software according to the invention, resulting in an initial allocation among mutual funds for a plan participant;

10 FIG. 2b-1 is a variant of FIG. 2b showing an alternative generation of retirement replacement income scenarios;

 FIG. 3 is a flow diagram showing a general portfolio reallocation process according to the invention;

15 FIG. 4 is a flow diagram showing a portfolio switching algorithm which takes into account the change over time of a plan participant's human capital;

 FIG. 4a is a detail of a variant of step 168 in FIG. 4, showing reallocation of assets given the presence of other, nonallocatable assets;

 FIG. 5 is a schematic block diagram of a plan management system according to the invention; and

20 FIG. 6 is a schematic architectural block diagram illustrating a representative computer architecture suitable for carrying out the invention.

DETAILED DESCRIPTION OF ILLUSTRATED EMBODIMENTS

Referring first to FIG. 1, a benefit plan management system indicated generally at 10 includes, as its basic components, an automated portfolio manager 12 and an automated independent financial advisor or consultant 14. To avoid conflicts of interest these two components are preferably owned and operated by different entities. The portfolio manager 12 invests funds given to it by or on behalf of a number of participants, which will typically consist of some or all of the employees of a company, trade union or institution. The portfolio or plan manager makes investments of its commingled participant funds in a number of investment vehicles 16 according to the needs of the participant portfolios 18 which it manages. There is established a separate portfolio 18 for each participant in the plan, and this portfolio 18 is instantiated as a separate database record for that participant. The sum of the portfolios 18 make up the benefit plan assets 19.

Each portfolio 18 will have in it an amount of assets which has been divided among the investment vehicles 16. The investment vehicles 16 have intentionally different degrees of risk and return and may include, for example, a stock mutual fund 20, a bond mutual fund 22 and a money market fund 24. A larger array of funds can be used, such as might include a large capitalization stock fund, a small capitalization stock fund which will be riskier but offer greater potential return than the "large cap" fund, and international funds. The number and identity of the investment vehicles 16 is set by an investment vehicle table 25, as will be later explained.

The way in which the assets of any particular portfolio 18 are divided among the permitted investment vehicles 16 is determined by advice (instructions)

from the preferably automated independent financial advisor 14, and these instructions may in turn incorporate directions or overrides from the individual participant or investor 26 of that portfolio 18.

The independent financial advisor 14 (a) advises the participant 26 of the level of retirement savings the participant has to make in order to probably achieve a desired level of replacement retirement income starting at a given retirement age, (b) makes recommendations as to the contents of a participant's portfolio 18 given the age, income and savings characteristics of the participant, and (c) directs the plan manager 12 to make investments as the advisor 14 and the participant 26 determine. In order to render this advice, the advisor 14 needs employee data from e.g. the human resources department 28 of the participant's employer, and certain additional data which may be submitted by the participant or investor 26. A record keeper 29 distinct from either the HR department 28 or the investor 26 may supply some or all of the needed information. The data from the human resources department 28 or record keeper 29 will typically include the date of birth of the participant, the participant's gender, the present salary of the participant, and the present level of contribution of that salary to the plan by or on behalf of the participant. Certain other data are obtained from the participant either directly through a paper form or an online interview process, or indirectly through the HR department 28 or from record keeper 29: these data include the taxable savings rate of the participant, the amount and characteristics of financial assets of the participant other than those managed by the portfolio manager 12, and a retirement age if different from a default (such as age 65). The data may also include more detailed information concerning participant periodic cash flows, which for example are

predicted to be less because certain other financial obligations (mortgage payments, college tuition) must be met, but which may be more when those financial obligations are discharged. These variances in cash flow might cause a variance in savings rates.

In making its calculations and recommendations, the financial advisor module 14 refers to an investment vehicle table 25 and an asset class table 30, which in actual practice may be combined. The investment vehicle table is a two-dimensional table which has a number of predetermined investment vehicles (typically, mutual funds of different kinds) along one dimension and a number of portfolio types along a second dimension. The portfolio types differ from each other in the relative amount of funds invested in each of the investment vehicles, and in the overall degree of risk that the investment vehicle mix represents. A more conservative portfolio type will be more heavily weighted in favor of fixed-income investment vehicles, while a more aggressive portfolio type will be more heavily weighted in favor of equity investments. In one embodiment there are provided seven portfolio types and ten different mutual funds; for each portfolio type the portfolio will index a percentage allocation to each of the mutual funds. On a periodic basis, such as yearly, this investment vehicle table will be replaced by an analyst to (1) substitute new mutual funds for others now in the table because of historic or predicted performance and (2) take into account any adjustment of an overall asset allocation target. For example, the analyst may decide that the overall asset allocation target should be 40% equity/60% fixed income instead of 42% equity/58% fixed income. After human capital is taken into account (discussed below) this may drive a reallocation of mutual funds in any particular portfolio type.

The asset class table 30 is a table of portfolio type versus asset class. The portfolio types will be the same as that for the investment vehicle table. Each portfolio type will have a percentage allocated to each of several of the asset classes, and this percentage changes from one portfolio type to another. In one embodiment there are five asset classes: money market, bond, large cap equity, small cap equity and international. The ten preselected mutual funds in table 25 are mapped on these asset classes according to their individual characteristics; some funds may bridge two or more asset classes and will be apportioned between them in a predetermined manner. The asset class table is used in determining optimum model portfolios for a participant once his or her human capital is taken into account.

The first major function of the independent financial advisor 14 is to help the plan participants decide at what rate they should invest and what investment mix they should be investing in. This is preferably done through an interview process which is diagrammed in FIGS. 2a-2c, with one variant thereof being shown in FIG. 2b-1. In a particularly preferred embodiment the interview is conducted on-line through a web site (see FIG. 5), but the interview could alternatively be conducted using paper forms and/or with the aid of the human resources department 29 of the employer.

The interview is initiated at 50. Certain data concerning the participant will already be known to the employer (or record keeper 29) and these are fetched at step 52: the current date (t), the current tax-deductible savings rate (SR_1), or at least that component of it that is made up by the participant's participation in the plan, the salary (I), the gender of the participant (needed to determine mortality and life

expectancy), and any defined benefit (DB) which will be payable by the employer to the participant upon retirement.

Other information is obtained from the participant at step 54. These other data include any component of the defined benefit income (DB) which will be available from any source other than the current employer; the participant's current taxable savings rate SR_2 ; any additional component of the participant's current tax-deductible savings rate SR_1 ; a desired retirement age RA , for which a default may be preset or upon which limitations may be placed by the employer; sources and types of financial wealth other than that component being managed by the employer in the plan; the initial replacement retirement income goal; the maximum tax-deductible savings rate SR_1 and taxable savings rate SR_2 which the participant can tolerate; and the maximum permissible retirement age.

Other data are obtained at step 56 by the independent financial advisor 14 from other tables or are derived. These include a vector of mortality rates ρ for each remaining year of the participant's life, the life expectancy T , the assumed discount rate r , and the predicted social security income SS earned by the participant.

At step 58, the advisor 14 calculates the value of human capital HC of the participant. One example of the calculation could use the following formula:

$$\text{Human Capital (t)} = \sum_{j=t}^T \frac{(S \times I_j + DB_j + SS_j) \times \prod_{i=t}^j (1 - \rho_i)}{(1+r)^{(j-t)}}$$

where

t = present age of the participant

I_j = real salary for year j. In one embodiment the real salary is assumed to be constant until retirement. In more sophisticated applications I_j can be allowed to vary in real terms through the participant's work life.

r = Real discount rate. In one embodiment the real interest rate on government bonds is used as the discount rate.

T = life expectancy for the participant.

ρ_i = mortality rate of the participant at age i.

S = savings rate, being the sum of the tax-deductible savings rate SR_1 and the taxable savings rate SR_2

DB_j = Defined Benefit Pension Income for year j.

SS_j = Social Security income for year j.

Alternatively, the human capital can be calculated according to the new

formula below:

$$\text{Human Capital (t)} = \sum_{j=t}^T \frac{(I_j + DB_j + SS_j) \times \prod_{i=t}^j (1 - \rho_i)}{(1+r)^{(j-t)}}$$

where

t = present age of the participant

I_j = real salary for year j.

r = Real discount rate.

T = the end age of the mortality table.

ρ_i = mortality rate of the participant at age i.

DB_j = Defined Benefit Pension Income for year j.

SS_j = Social Security income for year j.

Once the human capital (HC) of a participant has been calculated, at step 60 it is divided into different investment types or asset classes in order to determine what the overall assets of the participant presently are. Human capital is treated as if it were much like a fixed income investment. HC does not fluctuate widely and has characteristics similar to those of a bond, such as a relatively fixed

schedule of cash throughout a participant's life. But human capital has more "default
 risk" than a government bond: the participant could lose his or her job, become
 disabled, or have to accept work at a lower salary. Because of this nonzero default
 risk, the human capital component is treated as a distribution among at least two asset
 or investment types such as equity and fixed income, with the bulk of it being
 attributed to the more conservative asset type(s). In the illustrated embodiment, the
 human capital is allocated, 30%/70%, to equity and fixed income asset types. In a
 more sophisticated treatment, the human capital split may depend more on a
 participant's specific circumstances; for example, a tenured college professor will
 have a fixed income weight to his or her human capital that is much higher than the
 70% given. An advanced or more complex system would determine the HC split
 according to demographic and personal information inputs or estimate the risk, return
 and other characteristics of HC separate from those financial assets. (E.g., HC could
 be modeled as a separate distinct asset, instead of a combination of the financial
 assets).

At step 62, the present worth of a participant's overall wealth is
 calculated by summing his or her total financial wealth (savings, investments) and the
 total human capital. This overall wealth (ow) is allocated, at step 64, to the same
 investment types used for allocation of HC. At step 68, an equity component of
 financial wealth $fw(e)$ is derived by subtracting the equity component of human
 capital $HC(e)$ from the equity component of the overall wealth $ow(e)$. Similarly, a
 fixed income component of financial wealth, $fw(i)$, is derived by subtracting the
 human capital fixed income component $HC(i)$ from the fixed income component of
 the overall wealth, $ow(i)$. These calculations derive an optimum allocation of a

give a guide for equity/fixed income allocations for future investments. It is possible that the investor's human capital dominates his or her overall wealth, such that there is an insufficient amount of the investor's present financial wealth to shift the equity/income percentage back to optimum. If this is the case, the algorithm comes as close to optimum as it can, as by pinning financial wealth to 100% equity. An advanced or more complex embodiment would determine a participant's present financial wealth allocation through matching not only the equity/fixed income weights, but also the risk, return and other characteristics of the sum of financial wealth portfolio and human capital to the optimal allocation of overall wealth.

The illustration of the interview process continues in FIG. 2b. A beginning "model portfolio" (MP(0)) distributed among selected ones of the several available investment vehicles is derived at step 70, using the broader equity/fixed income financial wealth allocations determined at step 68. A mapping system is used to classify actual investments into broad asset classes. For each actual investment, the weight of each asset class is estimated. For example, one mutual fund could be considered to consist of 75% in large cap stocks, 10% in international, and 15% in cash. These weights are estimated using return and/or actual holding data of the fund.

The system then performs a series of iterations to arrive at the participant's optimum savings rate and retirement age given a retirement replacement income goal. At step 72 the algorithm queries whether this goal has already been met given the initial assumptions for the model portfolio MP(0). If so, the process branches to connector 2c. If not, then at decision step 74 the process asks if the tax-deductible savings rate SR_1 (such as investments made into an available 401(k) account) are already at maximum. If not, at step 76 the process will increment SR_1

and recalculate HC, the optimum allocations of the participant's financial wealth and future investments, a further model portfolio MP(i), and a new achievable income that can be obtained at a certain probability, such as 67%, is calculated. The process then returns to step 72, and these calculations repeat until SR₁ is maximized or the income goal is reached.

At step 78, assuming the retirement income goal has not yet been achieved, the system asks whether the taxable savings rate SR₂ is at maximum. If not, the process increments SR₂ at step 80, and recalculates HC, a new model portfolio MP(n), and probable achievable retirement replacement income. The process will again query, at step 82, whether the retirement income goal has been reached; if so the iterations will terminate and if not the process will return to step 78.

At step 84 the process asks whether the retirement age RA is at a maximum limit. If so, the process proceeds to connector 2c; if not, then at step 86 RA is incremented, and HC, a new model portfolio MP(n) and probable achievable income are recalculated. At step 88 the algorithm again asks whether the retirement income goal has been achieved. If this is the case, the process returns to step 84, else the process continues to connector 2c.

Now referring to FIG. 2c, which is a continuation of FIG. 2b, the process next sorts each of the iterations run in FIG. 2b in order of the starting model portfolio MP(0), and then the newly generated portfolios (MP(i)-MP(n)), in order of increasing SR₁, increasing SR₂, and increasing RA. These results are displayed to the participant. At step 92, the participant or investor is given the opportunity to reset maximum SR₂ and/or RA, and if she does so more iterations are calculated and displayed at step 94. If no further adjustments are desired, then at step 96 the

participant is next ready to select that combination of SR_1 and RA that best meets her needs.

At step 98, the automated financial advisor 14 (FIG. 1) takes the assumptions decided upon by the participant at step 96 (or, if the participant neglects to make these choices or to perform the interview at all, default assumptions) and instructs the portfolio manager 12 to make investments according to the investment allocation best suited to the participant. In conjunction with this at step 100 the financial advisor 14 recommends to the participant an optimum asset distribution of that component of the participant's financial wealth which is not under the control of the financial advisor/ portfolio manager. This terminates the initial interview process.

FIG. 2b-1 illustrates a variant by which a sheath of model portfolios $MP(0)$ - $MP(n)$ may alternatively be calculated. At step 70a, as before, a beginning model portfolio $MP(0)$ is calculated, together with a probable retirement income, for current tax-deductible savings rate SR_1 , taxable savings rate SR_2 , and current assumed retirement age RA . At step 72a, the routine asks whether the income goal of the investor has been achieved. If not, at step 74a the routine asks whether the retirement age is already set at a predetermined maximum period. If the retirement age is not yet maximized, at step 76a the retirement age is incremented by e.g. one year. Human Capital (HC), probable achievable income and a further model portfolio are then calculated at step 76a and the routine returns to step 72a. The loop of steps 72a, 74a and 76a will produce a set of model portfolios $MP(1)$ - $MP(n)$ in which the retirement age RA is incremented, until the retirement age reaches a maximum or the income goal of the investor is achieved.

Assuming that the income goal of the investor has not yet been met, the procedure next asks whether the tax-deductible savings rate SR_1 is already at a maximum at step 78a. If not, the tax deductible savings rate SR_1 is incremented, the human capital recalculated, a new model portfolio $MP(n)$ is derived, and a new probable achievable income is found. Procedure loop 78a, 80a, 82a continues, generating further model portfolios, until the tax-deductible savings rate SR_1 become a predetermined maximum or until the stated income goal of the investor is achieved.

If RA and SR_1 are maximized but the income goal of the investor is still not achieved, the procedure will enter a loop 84a, 86a, 88a. A final set of model portfolios is created in this loop until such time as SR_2 , the taxable savings rate reaches a maximum or until the income goal of the investor is achieved, whichever happens first. The procedure then continues as per the first illustrated embodiment (FIGS. 2a-2c).

In a further embodiment, a least "painful" solution is found by increasing savings rate and retirement age together rather than maximizing one of these three elements at a time.

An important aspect of the invention is illustrated in the process flowcharts of FIGS. 3 and 4, by which the assets of each participant portfolio are periodically reinspected and, unless prohibited to do so by the participant, reallocated. This reallocation of assets may be made by a system which also recommends beginning model portfolios and savings rates to a participant or investor, or it may be carried out irrespective of how the portfolio presented to it was originated.

In the reallocation process, at step 150, and at a first predetermined interval such as each quarter, the participant portfolio data are fetched by automated

financial advisor 14. These data, which include the market performance of the participant's assets among other things, are updated at step 151. At step 152 the advisor 14 reads the investment vehicle table 25, which is indexed by portfolio participant type, to see what investment vehicles should now be used. One or more investment vehicles in the table may have been replaced, and if so a set of initial investment instructions to the plan manager 12 is formulated. Then, at step 154, the process asks whether it has been at least three years (or any other predetermined interval) since a portfolio type has last been attributed to the investor. If so, then at step 156 a portfolio switching algorithm is called, which is illustrated in more detail in FIG. 4. If not, at step 158 the portfolio is rebalanced, among currently acceptable investment vehicles, to conform to the currently assigned participant portfolio type. Preferably, the recommendations of the automated independent financial advisor 14 are displayed to the participant at step 160, and at this point the participant can decide to change any of these recommendations. If after a predetermined period of time the investor or participant makes no changes, the recommended investment allocations become final. Once finalized, directions to the portfolio or plan manager 12 are transmitted at step 162.

According to a preferred embodiment of the invention, the participant is initially assigned to one of a predetermined number portfolio types. For example, there may be seven such portfolio types, differing from each other in the degree of risk thought acceptable given the participant's proximity to retirement age and other factors. Portfolio switching algorithm 156 (FIG. 4) reassesses the suitability of the assigned portfolio type given the participant's advancing age and possibly changed economic circumstances, and shifts the participant to an adjacent (typically, more

conservative) portfolio type if the current one is found not to fit as well as the new one.

At step 164, the participant's salary income I and nontaxable savings rate SRI are updated with data from the employer's human resources department or other record-keeping entity. The participant/investor's nonallocatable financial wealth (nfw, that part not managed by the plan) is obtained from the investor or the investor's record keeper 29. Then, at step 166, the participant's human capital is recalculated. This, in turn, is used to recalculate the optimum financial portfolio mix at step 168. This step also includes an updated portfolio balance and a mapping to different asset classes.

Oftentimes, the portfolio manager and the independent financial expert are only in charge of a part of the investor's portfolio. For example, the investor may have more than one 401(K) account, but the portfolio manager manages only one of these. This problem is resolved by creating two baskets: one for reallocatable assets and one for nonreallocatable assets. The non-reallocatable assets remain fixed while the allocatable assets are adjusted.

This process is illustrated in FIG. 4a, which shows an adjustment step 168a that is substituted for the recalculation step 168 in FIG. 4. In FIG. 4a, the allocatable financial wealth afw_1 is retrieved at step 250. This is the financial wealth under the control of the portfolio manager 12. The allocatable financial wealth afw_1 will have been allocated into two or more asset classes. In this example, there are only two asset classes, equity and fixed income, but in other examples there could be more than two asset classes, such as cash, international and "large cap" equity classes.

At step 252, the nonallocatable financial wealth of the investor, nfw_1 , is retrieved. The types of investment vehicles into which nfw_1 has been invested is inspected at step 254, and these assets are allocated among the same asset classes that are used to divide the allocatable financial wealth. One thereby obtains equity and fixed-income nonallocatable financial wealth components nfw_{e1} and nfw_{i1} . At step 256, an identity is made between the financial wealth nfw_1 prior to reallocation of assets and the financial wealth nfw_2 after reallocation. Both of these are equal to the allocatable financial wealth afw_1 plus the nonallocatable financial wealth nfw_1 .

The new ideal asset allocation between the asset classes is made at step 258; fw_{e2} and fw_{i2} are the ideal equity and fixed income asset class allocations, respectively. Then, at step 260, two more identities are assumed: the nonallocatable financial wealth in each asset class is assumed to remain the same, before and after the reallocation occurs. At step 262, the allocatable financial wealth afw_{e2} is found by subtracting the nonallocatable financial wealth nfw_{e2} from the total financial wealth fw_{e2} . However, if afw_{e2} turns out to be less than zero, it is reset to zero and the fixed income component of allocatable financial wealth afw_{i2} is equated to the total allocatable financial wealth afw_2 . By this last step, the allocatable financial wealth is allocated such that the overall portfolio comes closest to the optimum asset allocation. The routine then passes by step 266 to step 274. Otherwise, path 264 is used. At step 268, a similar subtraction is made on the fixed income asset class side to derive the new income component of allocatable financial wealth afw_{i2} as the difference between the nonallocatable financial wealth nfw_{i2} and the total income financial wealth fw_{i2} . If the subtraction results in a value for afw_{i2} that is less than zero, the program sets afw_{i2} to zero and sets afw_{e2} as equal to afw_2 . The routine then proceeds by path 272 to

step 274. Otherwise, the routine proceeds by path 270 to step 274. At step 274, one has obtained the new asset allocations afw_{e2} and afw_{i2} for the allocatable financial wealth afw_2 at the conclusion of the reallocation process. This routine then returns at step 276.

5 These asset classes are compared, at step 170, with the asset classes of the model portfolio for the portfolio type currently assigned to the participant, and to the asset classes of the model portfolio of the next adjacent model portfolio.

 At step 172, the algorithm asks whether the newly calculated financial portfolio mix is closer to either of the adjacent model portfolios than it is to the current model portfolio. If it is not, the portfolio switching algorithm ends. If it is, the participant or investor is switched to the next adjacent model portfolio type at step 174. The date at which the portfolio type has been last assigned, t_{MP} , is reset at step 176 before this routine ends. As so constructed, the portfolio switching algorithm should have brakes on radical change: for example, the portfolio is not switched any
 10 sooner than after a predetermined interval, preferably three years, and if there is any change the switch is made only to an adjacent portfolio type.

 In addition to taking in the (typically) declining value of the human capital of the investor, the above method also considers the market performance of the investor's assets when making adjustments in the portfolios. Market performance affects how much financial wealth the investor has. When financial wealth increases,
 20 the portfolio tends to become more conservative more quickly.

 FIG. 5 is a schematic block diagram of an overall plan management system 200. The automated independent financial advisor 14 may reside on a programmed, general-purpose computer 202 having so-called personal computer

5 (“PC”) architecture; alternatively, other computers may be used, an example being a minicomputer such as those made by Sun Microsystems. Referring to FIG. 6, a highly schematic internal architecture of the computer 202 is shown. In the preferred embodiment, the computer 202’s main logic is embodied by a general-purpose, programmable microprocessor 204, which in conventional practice will have an on-board memory cache (not shown) and which may be associated with one or more mathematics or other special-purpose coprocessors (not shown). The processing logic generally represented by processor 204 is connected by a bus structure 206 to the various other components of the computer 202. The schematic representation of bus 10 206 is shown in FIG. 6 as a simple and unitary structure, but in conventional practice, as is known to those in the art, there usually are several buses and communication pathways 206, operating at different speeds and having different purposes. Further, bus 206 may be segmented and controlled by respective bus controllers, as is also known in the art.

15 Computer 202 will also have a random access memory unit or units 208 connected to the bus 206. RAM 208 (which may be DRAM, SDRAM or other known types) typically has loaded into it the operating system of the computer 202 and executable instructions for one or more special applications designed to carry out the invention. Computer 202 also has electronic read-only memory 210 for storing 20 those programs such as the BIOS which are nonvolatile and persist after the computer 202 is shut down. In alternative embodiments of the invention, one or more components of the invention’s logic may be hard-wired into the ROM 210 instead of loaded as software instructions into RAM 208. ROM 210 can consist of or comprise electrically programmable read-only memory (EPROM), electrically erasable and

programmable read-only memory (EEPROM) of either flash or nonflash varieties, or other sorts of read-only memory such as programmable fuse or antifuse arrays.

In a typical architecture, a computer program suitable for carrying out the automated financial advisor component of the invention will be stored on a mass storage device 212, such as an optical disk or magnetic hard drive. A copy of the participant data used as a basis for portfolio selection will typically exist as a database on device 212, together with the investment vehicle table 25 and the asset class table 30 which are modified from time to time by personnel controlling the automated independent financial advisor 14. Bus 206 connects mass storage device 112 to RAM 108.

The computer 202 is connected to various peripheral devices used to communicate with an operator, such as display 214, keyboard 216 and mouse 218. The computer 202 also uses a communications device 220 such as a modem or a network card to communicate to other computers and equipment. The other computers herein described may have generally similar architecture but will be differently programmed to carry out their respective functions.

Returning to FIG. 5, the automated independent financial advisor server 202 can be connected to a web server 222, as by means of a hardwired connection 224 (such as an Ethernet connection) or by a wireless method (not shown). The web server acts as a host for a web site, which is the preferred interface used to perform the initial interview with each participant 26 (FIGS. 2a-2c) and which presents investment advice (portfolio allocations; FIGS. 3-4) to the participant for the participant's potential modification or even complete veto (by which he would

instruct advisor 14 to leave his portfolio as-is). This web site is typically remotely accessible by a computer 226 of a participant 26.

To obtain data for certain of its calculations, as described above, the independent financial advisor computer 202, typically resident on premises distinct from those of the employer, will communicate via the Internet or the like with a database server 228 of the employer's human resources department. When the advice is finalized the advisor system 202 will also transmit instructions via remote link 232 to portfolio manager computer 234, which makes electronic trades in conformance to advisor 14's instructions, stores the present status of the participant portfolios in a plan database 19, and informs advisor 14 of that status.

While the present invention has been illustrated in conjunction with the management of a qualified retirement plan, it also has application to the management of portfolios composed of nonqualified retirement savings, such as the assets of an investor outside of employer-sponsored retirement savings plans. In managing such nonqualified portfolios, information will typically not be obtained from an employer of the investor but rather from the investor himself or herself or an agent of the investor.

In summary, a novel investor portfolio asset management system has been shown and described. An automated, independent financial advisor calculates and applies a human capital component of the investor's overall worth in order to determine an optimum allocation of the financial assets of the participant among several asset classes and investment vehicles. The financial advisor relays investment instructions based on these calculations and investor input, if any, to a plan manager for execution of trades to conform the investor portfolio to the optimum allocation.

Further, the independent financial advisor automatically reallocates portfolio assets to take into account the declining value of the investor's human capital over time. While preferred embodiments of the invention and their technical advantages have been described above and illustrated in the appended drawings, the invention is not limited thereto but only by the scope and spirit of the claims which follow.

5

10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42
 43
 44
 45
 46
 47
 48
 49
 50
 51
 52
 53
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65
 66
 67
 68
 69
 70
 71
 72
 73
 74
 75
 76
 77
 78
 79
 80
 81
 82
 83
 84
 85
 86
 87
 88
 89
 90
 91
 92
 93
 94
 95
 96
 97
 98
 99
 100
 101
 102
 103
 104
 105
 106
 107
 108
 109
 110
 111
 112
 113
 114
 115
 116
 117
 118
 119
 120
 121
 122
 123
 124
 125
 126
 127
 128
 129
 130
 131
 132
 133
 134
 135
 136
 137
 138
 139
 140
 141
 142
 143
 144
 145
 146
 147
 148
 149
 150
 151
 152
 153
 154
 155
 156
 157
 158
 159
 160
 161
 162
 163
 164
 165
 166
 167
 168
 169
 170
 171
 172
 173
 174
 175
 176
 177
 178
 179
 180
 181
 182
 183
 184
 185
 186
 187
 188
 189
 190
 191
 192
 193
 194
 195
 196
 197
 198
 199
 200
 201
 202
 203
 204
 205
 206
 207
 208
 209
 210
 211
 212
 213
 214
 215
 216
 217
 218
 219
 220
 221
 222
 223
 224
 225
 226
 227
 228
 229
 230
 231
 232
 233
 234
 235
 236
 237
 238
 239
 240
 241
 242
 243
 244
 245
 246
 247
 248
 249
 250
 251
 252
 253
 254
 255
 256
 257
 258
 259
 260
 261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303
 304
 305
 306
 307
 308
 309
 310
 311
 312
 313
 314
 315
 316
 317
 318
 319
 320
 321
 322
 323
 324
 325
 326
 327
 328
 329
 330
 331
 332
 333
 334
 335
 336
 337
 338
 339
 340
 341
 342
 343
 344
 345
 346
 347
 348
 349
 350
 351
 352
 353
 354
 355
 356
 357
 358
 359
 360
 361
 362
 363
 364
 365
 366
 367
 368
 369
 370
 371
 372
 373
 374
 375
 376
 377
 378
 379
 380
 381
 382
 383
 384
 385
 386
 387
 388
 389
 390
 391
 392
 393
 394
 395
 396
 397
 398
 399
 400
 401
 402
 403
 404
 405
 406
 407
 408
 409
 410
 411
 412
 413
 414
 415
 416
 417
 418
 419
 420
 421
 422
 423
 424
 425
 426
 427
 428
 429
 430
 431
 432
 433
 434
 435
 436
 437
 438
 439
 440
 441
 442
 443
 444
 445
 446
 447
 448
 449
 450
 451
 452
 453
 454
 455
 456
 457
 458
 459
 460
 461
 462
 463
 464
 465
 466
 467
 468
 469
 470
 471
 472
 473
 474
 475
 476
 477
 478
 479
 480
 481
 482
 483
 484
 485
 486
 487
 488
 489
 490
 491
 492
 493
 494
 495
 496
 497
 498
 499
 500
 501
 502
 503
 504
 505
 506
 507
 508
 509
 510
 511
 512
 513
 514
 515
 516
 517
 518
 519
 520
 521
 522
 523
 524
 525
 526
 527
 528
 529
 530
 531
 532
 533
 534
 535
 536
 537
 538
 539
 540
 541
 542
 543
 544
 545
 546
 547
 548
 549
 550
 551
 552
 553
 554
 555
 556
 557
 558
 559
 560
 561
 562
 563
 564
 565
 566
 567
 568
 569
 570
 571
 572
 573
 574
 575
 576
 577
 578
 579
 580
 581
 582
 583
 584
 585
 586
 587
 588
 589
 590
 591
 592
 593
 594
 595
 596
 597
 598
 599
 600
 601
 602
 603
 604
 605
 606
 607
 608
 609
 610
 611
 612
 613
 614
 615
 616
 617
 618
 619
 620
 621
 622
 623
 624
 625
 626
 627
 628
 629
 630
 631
 632
 633
 634
 635
 636
 637
 638
 639
 640
 641
 642
 643
 644
 645
 646
 647
 648
 649
 650
 651
 652
 653
 654
 655
 656
 657
 658
 659
 660
 661
 662
 663
 664
 665
 666
 667
 668
 669
 670
 671
 672
 673
 674
 675
 676
 677
 678
 679
 680
 681
 682
 683
 684
 685
 686
 687
 688
 689
 690
 691
 692
 693
 694
 695
 696
 697
 698
 699
 700
 701
 702
 703
 704
 705
 706
 707
 708
 709
 710
 711
 712
 713
 714
 715
 716
 717
 718
 719
 720
 721
 722
 723
 724
 725
 726
 727
 728
 729
 730
 731
 732
 733
 734
 735
 736
 737
 738
 739
 740
 741
 742
 743
 744
 745
 746
 747
 748
 749
 750
 751
 752
 753
 754
 755
 756
 757
 758
 759
 760
 761
 762
 763
 764
 765
 766
 767
 768
 769
 770
 771
 772
 773
 774
 775
 776
 777
 778
 779
 780
 781
 782
 783
 784
 785
 786
 787
 788
 789
 790
 791
 792
 793
 794
 795
 796
 797
 798
 799
 800
 801
 802
 803
 804
 805
 806
 807
 808
 809
 810
 811
 812
 813
 814
 815
 816
 817
 818
 819
 820
 821
 822
 823
 824
 825
 826
 827
 828
 829
 830
 831
 832
 833
 834
 835
 836
 837
 838
 839
 840
 841
 842
 843
 844
 845
 846
 847
 848
 849
 850
 851
 852
 853
 854
 855
 856
 857
 858
 859
 860
 861
 862
 863
 864
 865
 866
 867
 868
 869
 870
 871
 872
 873
 874
 875
 876
 877
 878
 879
 880
 881
 882
 883
 884
 885
 886
 887
 888
 889
 890
 891
 892
 893
 894
 895
 896
 897
 898
 899
 900
 901
 902
 903
 904
 905
 906
 907
 908
 909
 910
 911
 912
 913
 914
 915
 916
 917
 918
 919
 920
 921
 922
 923
 924
 925
 926
 927
 928
 929
 930
 931
 932
 933
 934
 935
 936
 937
 938
 939
 940
 941
 942
 943
 944
 945
 946
 947
 948
 949
 950
 951
 952
 953
 954
 955
 956
 957
 958
 959
 960
 961
 962
 963
 964
 965
 966
 967
 968
 969
 970
 971
 972
 973
 974
 975
 976
 977
 978
 979
 980
 981
 982
 983
 984
 985
 986
 987
 988
 989
 990
 991
 992
 993
 994
 995
 996
 997
 998
 999
 1000
 1001
 1002
 1003
 1004
 1005
 1006
 1007
 1008
 1009
 1010
 1011
 1012
 1013
 1014
 1015
 1016
 1017
 1018
 1019
 1020
 1021
 1022
 1023
 1024
 1025
 1026
 1027
 1028
 1029
 1030
 1031
 1032
 1033
 1034
 1035
 1036
 1037
 1038
 1039
 1040
 1041
 1042
 1043
 1044
 1045
 1046
 1047
 1048
 1049
 1050
 1051
 1052
 1053
 1054
 1055
 1056
 1057
 1058
 1059
 1060
 1061
 1062
 1063
 1064
 1065
 1066
 1067
 1068
 1069
 1070
 1071
 1072
 1073
 1074
 1075
 1076
 1077
 1078
 1079
 1080
 1081
 1082
 1083
 1084
 1085
 1086
 1087
 1088
 1089
 1090
 1091
 1092
 1093
 1094
 1095
 1096
 1097
 1098
 1099
 1100
 1101
 1102
 1103
 1104
 1105
 1106
 1107
 1108
 1109
 1110
 1111
 1112
 1113
 1114
 1115
 1116
 1117
 1118
 1119
 1120
 1121
 1122
 1123
 1124
 1125
 1126
 1127
 1128
 1129
 1130
 1131
 1132
 1133
 1134
 1135
 1136
 1137
 1138
 1139
 1140
 1141
 1142
 1143
 1144
 1145
 1146
 1147
 1148
 1149
 1150
 1151
 1152
 1153
 1154
 1155
 1156
 1157
 1158
 1159
 1160
 1161
 1162
 1163
 1164
 1165
 1166
 1167
 1168
 1169
 1170
 1171
 1172
 1173
 1174
 1175
 1176
 1177
 1178
 1179
 1180
 1181
 1182
 1183
 1184
 1185
 1186
 1187
 1188
 1189
 1190
 1191
 1192
 1193
 1194
 1195
 1196
 1197
 1198
 1199
 1200
 1201
 1202
 1203
 1204
 1205
 1206
 1207
 1208
 1209
 1210
 1211
 1212
 1213
 1214
 1215
 1216
 1217
 1218
 1219
 1220
 1221
 1222
 1223
 1224
 1225
 1226
 1227
 1228
 1229
 1230
 1231
 1232
 1233
 1234
 1235
 1236
 1237
 1238
 1239
 1240
 1241
 1242
 1243
 1244
 1245
 1246
 1247
 1248
 1249
 1250
 1251
 1252
 1253
 1254
 1255
 1256
 1257
 1258
 1259
 1260
 1261
 1262
 1263
 1264
 1265
 1266
 1267
 1268
 1269
 1270
 1271
 1272
 1273
 1274
 1275
 1276
 1277
 1278
 1279
 1280
 1281
 1282
 1283
 1284
 1285
 1286
 1287
 1288
 1289
 1290
 1291
 1292
 1293
 1294
 1295
 1296
 1297
 1298
 1299
 1300
 1301
 1302
 1303
 1304
 1305
 1306
 1307
 1308
 1309
 1310
 1311
 1312
 1313
 1314
 1315
 1316
 1317
 1318
 1319
 1320
 1321
 1322
 1323
 1324
 1325
 1326
 1327
 1328
 1329
 1330
 1331
 1332
 1333
 1334
 1335
 1336
 1337
 1338
 1339
 1340
 1341
 1342
 1343
 1344
 1345
 1346
 1347
 1348
 1349
 1350
 1351
 1352
 1353
 1354
 1355
 1356
 1357
 1358
 1359
 1360
 1361
 1362
 1363
 1364
 1365
 1366
 1367
 1368
 1369
 1370
 1371
 1372
 1373
 1374
 1375
 1376
 1377
 1378
 1379
 1380
 1381
 1382
 1383
 1384
 1385
 1386
 1387
 1388
 1389
 1390
 1391
 1392
 1393
 1394
 1395
 1396
 1397
 1398
 1399
 1400
 1401
 1402
 1403
 1404
 1405
 1406
 1407
 1408
 1409
 1410
 1411
 1412
 1413
 1414
 1415
 1416
 1417
 1418
 1419
 1420
 1421
 1422
 1423
 1424
 1425
 1426
 1427
 1428
 1429
 1430
 1431
 1432
 1433
 1434
 1435
 1436
 1437
 1438
 1439
 1440
 1441
 1442
 1443
 1444
 1445
 1446
 1447
 1448
 1449
 1450
 1451
 1452
 1453
 1454
 1455
 1456
 1457
 1458
 1459
 1460
 1461
 1462
 1463
 1464
 1465
 1466
 1467
 1468
 1469
 1470
 1471
 1472
 1473
 1474
 1475
 1476
 1477
 1478